Fume Hood Patent Review and Barrier Identification

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I. Abstract

A fume hood may be generally described as a ventilated, enclosed workspace intended to capture, contain, and exhaust fumes, vapors, and particulate matter generated inside the enclosure. The purpose of a fume hood is to draw fumes and other airborne matter generated within a work chamber away from a worker, so that inhalation of contaminants is ideally eliminated. The concentration of contaminants to which a worker is exposed should be kept as low as possible and should never exceed the particular contaminant's safety threshold limit value. Such safety thresholds and other factors relating to testing and performance of laboratory fume hoods are prescribed by government and industry standards. The Environmental Energy Technologies Division at LBNL has developed a new laboratory fume hood technology to reduce energy expenditure while maintaining necessary containment and safety conditions. Before a completed product can be released, many steps must be taken to ensure full legal protection and, most importantly, to guarantee maximum safety for those using the hood. Gaining a patent and overcoming potential standards and code barriers are essential goals to the completion of the LBNL low flow fume hood.

II. Description of Low-Flow Fume Technology

The new low-flow fume hood technology developed here at LBNL's Environmental Energy Technologies Division seeks to achieve greater safety and containment while conserving energy as well. This drastically reduces the exhaust air volume and in turn reduces the energy used by the exhaust while effectively maintaining safe levels of containment. This is a breakthrough development and the patent application submitted by LBNL is still pending. During this pending period I will aid the Applications Team in the patent process.

III. Fume Hoods and Prior Patent Art

First, prior patent art and applications in this area must be researched and compiled in preparation for the emergence of this technology. I have been researching publications and patent databases to prepare a documented report with references of all relevant fume

hood technologies. When I arrived at the laboratory in early June we were entering the office action stage of the Patent process (a complete flow chart version of the process is attached). Typically after a patent application has been filed the Patent Trademark Office (PTO) will respond with the first of what is called an office action. Typically, an application is comprised of two main parts: the specifications and the claims on the invention. In the current office action we are re-evaluating the claims that were made in the original application. On May 11, 1999 we received the response back from the PTO citing nine prior patents (7 US, 2 Canadian) against the claims we made for our fume hood technology. From then on we have done extensive comparative analyses to the prior art.

[material removed as confidential]

IV. Identifying Fume Hood Compliance Barriers

As my supervisor Geoffrey Bell seeks to complete the fume hood, all aspects of the new fume hood technology must be researched to test compliance with relative laboratory safety and testing codes and standards. Part of my task was to identify and analyze barriers to applying the low-flow fume hood technique with respect to relevant building codes and regulations: Uniform Building, Mechanical and Electrical Codes (all states); OSHA regulations; Fire and Safety regulations (specifically NFPA); and "standard" design guidelines (ASHRAE and ACGIH). In particular, stringent face velocity tests, such as required by the ASHRAE-110 test, serve as barriers to our low-flow energy efficient fume hood and ways to overcome them should be devised. I studied performance guidelines for fume hoods as primary laboratory environmental safety devices and looked to aid in the development of methods to overcome institutionalized design practices that will impact application of the low-flow fume hood.

Much of my task was concentrated on identifying relative codes and standards. I have compiled a abridged outline of the main codes and standards that are widely accepted in industry and academia:

- OSHA 29 CFR
  - Hood face velocity - 60-100 fpm
  - Monitoring device to confirm adequate performance
  - 4-12 room air changes/hour

- ACGIH – Industrial Ventilation
  - Fume hood face velocities between 60-100 fpm
  - Maximum of 125 fpm for radioisotope hoods
  - Duct velocities of 1000-2000 fpm for vapors, gasses, and smoke
  - Well designed fume hood containment loss < 0.10 ppm

- SAMA-SEFA 1-1996
  - Class A Fume Hood - materials of extreme toxicity ~ 125-150 fpm
  - Class B Fume Hood - standard lab chemicals ~ 100 fpm

- Class C Fume Hood - materials of low toxicity ~ 75-80 fpm

- NFPA 45
  - Hood velocities to prevent escape of contaminants
  - Hood air maintained at negative pressure to the lab air
  - Laboratory hoods should not be relied on for explosion protection
  - Exhaust air from fume hoods should not be recirculated
  - Energy conservation devices to be designed in accordance with ANSI Z9.5

- ANSI Z9.5
  - Vertical stack discharge @ 2000-3000 fpm
  - Hood velocities of 80-120 fpm are adequate
  - Hoods to be equipped with real-time monitoring device
  - ASHRAE 110 is the recommended test

Each of these standards leads into a progression that eventually points to the benchmark of fume hood testing, the ASHRAE 110 test. This is a threefold test that thoroughly tests all aspects of the hood.

A. Calculate the Average Velocity
   - Grid of 1x1 ft squares is formed over sash opening
   - Velocity readings are taken in grid and averaged

B. Flow Visualization
   - Test for reverse air flows and dead air space
   - Titanium Tetrachloride applied in hoods interior
   - Any movement towards the face or no movement at all is noted

C. Tracer Gas
   - Tracer gas SF_6 is released at established rate within the hood
   - Gas monitored in breathing zone of mannequin
   - Performance rate determined release rate of tracer gas and average exposure in breathing zone
   - Test for exposure rate at various positions

This is a meticulous test that can also be rather time consuming and expensive. Most people will just stop with the face velocity tests, thinking that that will be adequate enough to test for containment. This is coupled with the fact that ASHRAE 110 does not specifically stipulate what face velocities are acceptable and instead most of the common standards recommendations of 100 fpm face velocity are then used. This serves as our most serious barrier at this point. Cal-OSHA is very stringent about maintaining a face velocity of about 60 fpm. Our current hood configuration measures a face velocity of around 30 fpm. Upon hearing this, most dismiss our hood as being unsafe, yet we have passed the flow visualization and tracer gas tests that are far superior for determining containment and safety.

V. Contacts with Fume Hood Specialists

I began contacting several industrial hygienists, EH&S personnel, and other experts in the fields of fume hood testing and certification. I was primarily interested to see if they could aid me in developing methods or recommendations to overcome the institutionalized design practices that might impact the application of the low-flow fume hood. I classified my contacts into related groups of individuals.

ASHRAE Contacts

The detailed contact information of each individual is attached in the appendix. First, I began to initiate contact with the people at ASHRAE and those who are involved the ASHRAE 110 standard. I got in touch with the ASHRAE technical services representative, Martin Wieland. I was mainly interested in clarifying a few issues about the test. I needed to know if it was indeed a three-fold test in which all three parts needed to be completed. In addition, the actual ASHRAE 110 test does not specify an actual minimum face velocity that should be achieved. Unfortunately, Mr. Wieland was not so timely in his response. I finally heard back from him about one month later. He actually told me that the flow visualization and tracer gas tests were the ones that proved containment and that the face velocity test was just used for a method of comparison or standardization between hoods. He then said that he was just involved in the administration of ASHRAE and that the person I needed to talk to was Edgar Galson, the standards chair on the ASHRAE TC9.10 committee. I then got in contact with Mr. Galson to ask him about the recent ASHRAE 1999 annual meeting technical program. Forum 21 of this meeting specifically addressed the face velocity issue. I finally heard from him over a month later saying that he had retired and has not kept up with recent developments. He then referred me to Gerhard Knudson and mentioned that there was no doubt in his mind that he was the most competent engineer for fume hoods. At this point I was not too pleased with the responsiveness of the ASHRAE people and I also was aware of our previous contact with Mr. Knudson so I moved on to another line of contact.

CETA Contacts

The second group of individuals I contacted was the members of the Controlled Environment Testing Association (CETA). I first heard back from Mick Gordon of Fort Dodge Laboratories in Iowa. He faxed me an in depth laboratory airflow standards guide that was compiled by Phoenix Controls. In addition, he also faxed me part of the 1995 ASHRAE Applications Handbook and a couple other articles relative to fume hoods performance, testing, and standards. All can be found attached in the appendix. The most beneficial contact came from Ms. Karen von Holtz from CSI Testing in Minneapolis, MN. She gave me references to two colleagues that has worked with in the past that are extensively involved with fume hoods. The first one I talked to was Charles Dodson from C-Scan Technologies in Scottsdale, AZ. Mr. Dodson is the president of the Internal Air Filtration Certification Association (IAFCA) and said that they would be setting their standards for certification soon. He seemed pretty well versed on many of the manufacturers in the industry. He suggested that one way to try and bypass the stringent face velocity tests would be to calibrate our fume hood against a conventional hood at low face velocities and compare containment. He said that he would be interested in seeing our results. The next contact from Karen was Mr. Wally Witt from Agapy Inc. Mr. Witt just seemed to know the common standards and said that he only

has used the face velocity and flow visualization tests. He did refer me to the most beneficial contact I have had thus far, Mr. Thomas Smith of Exposure Control Technologies (ECT) in N. Carolina. Mr. Smith is very knowledgeable and very informative on fume hoods. His company, ECT, does testing for Industrial Hygiene certification with emphasis on safe, reliable, and efficient means. He just attended a conference in which he spoke about data he compiled on over 1,600 ASHRAE 110 test. His PowerPoint presentation is attached as well. He stated that increasing the face velocity or reducing the sash does usually increase containment but that face velocities in the range of 80-100 fpm still are not strongly correlated with containment. 85% of his hoods passed the tracer gas test regardless of what the face velocity was measured as. In fact, nearly 13% of the hoods that had face velocity test measurements between 80-150 fpm did not pass the tracer gas test. He seemed rather interested in our low flow fume hood because he is continually looking for new safe, energy-efficient fume hoods to recommend to industries he's involved with. He is coming out here to San Jose and Monterrey in October and is interested in seeing our hood. It would probably be beneficial to remain in contact with him. I have already referred him to Geoffrey Bell and Dale Sartor.

EH&S Officials

The third class of contacts was the respective Industrial Hygienists and Environmental, Health, & Safety officials at most of the University of California campuses and various national laboratories. If our low flow fume hood is to be used in any of their laboratories then we should be knowledgeable of the relative standards and codes that they adhere to. First I talked with Marwan Badar, the Ventilation System Manager at Oak Ridge National Laboratory. Specifically, he is involved with the removal of air pollutants and toxins from laboratory environments. He emphasized OSHA's importance, but he said that if we prove containment with no exposure then we will not be liable to be fined. Thus, our low face velocity is exempted in cases of containment. However, he said this was true for OSHA, but that still does not help us for Cal-OSHA. Mr. Badar also seemed rather interested in our technology and would like to remain in contact. I then talked with John Chan an Industrial Hygienist with UC Irvine. He expressed a desire to see our hood and was rather supportive. He was concerned with how many of the fume hood tests are static and do not concentrate on movement around the hood. He faxed me a packet put together by Landis & Gyr that is a complete compilation of Laboratory Ventilation Systems standards. He also included the slides from a Phoenix Controls presentation on fume hoods and his own sheet on safety vs. energy efficiency in Laboratory Fume Hoods. Next, I talked with Brian Oatman from UC Davis. He too, was concerned with static testing, especially at low face velocities. He sent me a fax delineating the campus standards and design guide for Davis and presumably the other UC campuses. I talked with most of the other UC EH&S personnel and they all seemed to express similar viewpoints. Their contact information can be found in the appendix.

MSU – EPICenter "Green Building" Pilot Facility

The final group that I have been in contact with is part of the EPICenter "Green Building" Pilot Facility at Montana State University. I have been contacting them to

discern the relative codes and standards that our low flow fume hood will have to be in compliance with. I initially contacted Kath Williams, the head of the "Green Building" project. She was very helpful and gave me the contact numbers of several people that eventually trickled me down to the actual facilities engineer, Jeff Davis, that is in charge of the standards and codes for the project. Upon talking with Mr. Davis, he just mentioned the common standards such as ANSI Z9.5 and OSHA. He seemed more intrigued with the issue of heat recovery for many of the energy efficient technologies that were going to be implemented into the "Green Building". It was somewhat difficult to get a hold of many of the "Green Building" workers, so it would be beneficial to try and improve the communication with them.

VI. Conclusion

I have wrapped up most of the patent research that I have done and attached it in the appendix. I have also completed most of the contacts that I have sought to finish. Hopefully, the second office action will turn out positive and advance us to the next stage of the patent process. As for the standards, the face velocity issue is still widely disputed and Cal-OSHA does not seem willing to consider altering that standard for a few years. However, we have drawn much support from many of the contacts we have made, especially since we can effectively prove containment using the flow visualization and tracer gas tests. The face velocity issue is an important barrier, yet I feel that our biggest issue is with the patent. I feel like we are in a Catch-22. We cannot persuade anyone that our technology works unless we tell them how it works. Yet we cannot tell them how it works until we have legal protection. Hopefully, we can make progress in the patent area by the end of the year. From here, the most important contact to maintain would be with Thomas Smith of ECT, especially if he is going to come out here for a demo in October. If we manage to build on the contact relations we have made and keep getting the support that many have expressed, then that will be the first step towards lessening the negative effects of the strict face velocity standards. It will pave the way for the eventual success of the low flow fume hood.

Contact List

ASHRAE

- Martin Wieland
  Title: Administrator Technical Services
  Contact: (404) 636-8400
- Edgar Galson
  Title: Standards Chair ASHRAE TC 9.10
  Contact: Galson Corp.
  236 Lockwood Road
  Syracuse, NY 13214
  (315)446-0224 (tel.)
  (315)437-0509 (fax.)
  egalson@aol.com
  Background: Referred to as a key ASHRAE contact even though he is supposedly retired.

CETA Affiliates

- See the attached sheet with the CETA members contact info.
- Charles Dodson
  Title: C-Scan Tech. Inc., President of IAFCA
  Contact: 8420 E. San Marino Dr.
  Scottsdale, Arizona 85258
  cscan12@aol.com
- Wally Witt
  Title: Agapy Inc.
  Contact: (800)829-0293

Background: He referred me to Thomas Smith of ECT

- Thomas Smith
  Title: Exposure Control Technologies (ECT)
  Contact: 231-c E. Johnson
  Cary, N. Carolina 27513
  (919)319-4290 (tel.)
  (919)319-4291 (fax.)
  tcsmith@aol.com
  Background: Very knowledgeable in the filed of fume hoods. He was very informative and responsive. He is interested in our low flow fume hood and looks to see a demo in October

EH&S Contacts

- Marwan Badar
  Title: Ventilation System Manager, Oak Ridge National Laboratory
  Contact: badarm@ornl.gov
  Background: Stated that OSHA face velocity test can be exempted if you prove containment
- Brian Oatman
  Title: Standards and Laws, UC Davis
  Contact: (530)752-1493
- John Chan
  Title: Industrial Hygienist (IH) UC Irvine
  Contact: (949)824-7101
  Background: Very interested in our fume hood and would like to get the opportunity to see a demo. Very responsive to my questions. Concerned with the statics of many tests and how they aren't good measures of containment.
- Paul Giering
  Title: IH , UC Riverside
  Contact: (909)787-5892
- Kevin Kaboli
  Title: IH, UC Santa Barbara
  Contact: (805)893-8787 (tel.)
  (805)893-8659 (fax.)
  Kevin.Kaboli@ehs.ucsb.edu
  Background: Came to see a demo on August 5th
- Joe Raab
  Title: IH, UCLA
  Contact: (310)794-3636
- Buddy Morris

Title: IH, UC Santa Cruz
Contact: (831)459-4454

MSU EPICenter "Green Building" Pilot Facility

- Kath Williams
  Title: Head of "Green Building" project
  Contact: (406)994-7713
- Jeff Shada
  Title: Director of Risk Management
  Contact: (406)994-2711
  shada@montana.edu
- Jeff Butler
  Title: Facilities
  Contact: (406)994-5471
  jbutler@facilities.montana.edu
  Background: Referred to by Kath Williams
- Cecilia Vaminam
  Title: Facilities Manager for "Green Building"
  Contact: (406)994-5449
  crv@facilities.montana.edu
  Background: Has much of the responsibility for organizing the "Green Building" project
- Jeff Davis
  Title: Facilities Engineer
  Contact: (406)994-5470
  Background: Referred to him by Cecilia Vaminam as the main facilities engineer that is in charge of standards compliance

VII. Appendix

A. Contact List

B. "Laboratory Airflow Controls Engineering Guide"
   Sent from Mick Gordon of Fort Dodge Laboratories

C. "Laboratory Ventilation Control"

D. "Laboratory Ventilation Systems: Codes and Standards"
   Sent from John Chan of UC Irvine

E. "UC Davis Standards for Laboratory Fumehoods"
   Sent from Brian Oatman of UC Davis

F. Compilation of Standards:
   - ACGIH
   - USDA Laboratory Fume Hood Requirements
   - California CFR
   - Laboratory Ventilation Standards

G. "Use of Average Face Velocity as an Indicator of Hood Performance"
   Sent from Thomas Smith of Exposure Control Technologies

H. Patent Information
   - Correspondence from James Austin
   - Patent and Trademark Office Action Response
   - Patent Application – "Energy Efficient Laboratory Fume Hood" Helmut Feustel
   - Patents Cited Against Us in the Office Action: A-N